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Several substantive results were found during the research period, bearing on mixing processes and percolation theory. A counter example to the o - mixing weak Bernoulli conjective was discovered. Polya urn methods were successfully applied to rate functions for dependent processes. In an important bio-systems application, the nervous system of the sea slug was found to be chaotic.

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Final Technical Report for AFOSR Grant #88 - 0105
Robert M. Burton

(1) Percolation. Together with M. Keane, the following results have been shown: (i) any [dependent] percolation model on the d-dimensional lattice, that satisfies finite energy and stationarity has either a unique infinite cluster or else no infinite cluster of a given color; (ii) each cluster of any percolation model on the d-dimensional lattice has a well-defined density; (iii) in the 2-lattice with site percolation the infinite clusters are arranged in "ribbons" that foliate the 2-lattice into an array of strips [20, 29].

(2) Random maps. Together with G. Keller, conditions for there to be a unique invariant measure for place dependent iterated function system have been found. In the first case monotone assumptions are used. In the second case coupling arguments are used to show that process is weak Bernoulli (absolutely regular). This is specifically applied to learning models where the probability of choosing a given map is not assumed to bounded away from one nor were the maps assumed to be contractions. In addition, a very simple argument has been found with U. Rössler that shows iid affine maps of the form Ax+b with finite second moments and with $\mathbf{E}[A^t A]$ contractive have an attracting invariant measure with convergence of second moments [24, 35].

(3) Mixing and determinism. A stationary process which is bilaterally deterministic, strongly mixing and finite state has been constructed extending work of Ornstein and Weiss as well as Bradley. This was joint with M. Denker and M. Smorodinsky. A related example constructed with M. Denker and D. Fiebig has the property of being ϕ-mixing but not very weak Bernoulli with rate O(1/n) [32, 33].

(4) Positive and weak dependence. Easy conditions that determine when an exchangeable random vector or process is weakly associated are found in joint work with A. R. Dabrowski. These depend on the 3-state factors of the process. These conditions are applied to the match set distribution (i.e. the fixed points of a random permutation) and to Polyà urn models. In the case that the exchangeable vector may be extended to a process so that de Finnetti's Theorem applies weakly associated is shown to imply association. In joint work with H. Dehling, we give large deviation results and computations of rate functions for some weakly dependent processes [30, 22].

(5) Neural networks and chaos. In joint work with G. Mpitsos, a neurophysiologist, neural behavior in a functioning nervous system of a sea slug is shown experimentally to have the properties of chaos. We think chaotic processes (i.e. low-dimensional processes with strong mixing properties) are important to the transmission and storage of information in biological systems. We have studied connectionist neural networks, especially back-propagation, to aid our understanding of biological and human constructed systems. In these studies we describe how information is stored with a view toward larger scale systems and give an analogy with continuous state spin glass models of statistical physics. Also a use of noise to enhance learning is suggested and studied. This algorithm differs from simulated annealing in that it is time-invariant and proportional to the error or energy level. These ideas about learning and chaos are also expect to be relevant to evolution [17, 18, 25, 26, 34].

(6) Control theory. Improved conditions for stability of controlled bilinear systems both stochastic and deterministic, have been found in joint work with R. Mohler and X. Yang. These apply to some examples that are well-known but not covered by previous theory [21, 23, 31].

Note: references cited are in the enclosed curriculum vitae